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THE FUTURE OF THE DEMOCRATIC REPUBLIC OF THE CONGO(DRC) WITHOUT ITS MINERAL RESOURCES: WOOD AS A CIVIL ENGINEERING MATERIAL FOR THE DEVELOPMENT OF THIS COUNTRY

Earth Science

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ABSTRACT

The realization of civil engineering works always produces impacts on the economic and social development of a given region. Some of these impacts can be positive and others negative. In the majority of cases, the options that exist, in relation to the design and project of these works, make it possible to establish a link between the realization of these works, and the materials used for these works while preserving the environment. To illustrate that it is possible to link the development of a region with civil engineering works, this article uses a few examples of materials used in the realization of these works, including wood, which is a natural renewable source that we find in vast areas in most provinces of the Democratic Republic of Congo being poorly exploited, an optimal management of these woods can effectively contribute to the development of this large country and consequently of Central Africa.

KEYWORDS

Wood, Materials, works, civil engineering, development, Country

INTRODUCTION

Central Africa, in general, and the Democratic Republic of Congo in particular, being in the process of development, is particularly concerned by this subject; given that for the economic and social development of the populations Civil Engineering works are really indispensable, in addition these works provide more significant conditions of economic production and social welfare in the most developed countries. In some cases, these works are exclusively aimed at protecting people and property from natural disasters and their impacts, as is the case of stabilization works on natural slopes, dams for flood control and for the retention of solid materials, with a view to protecting downstream areas, especially people and property. In other cases, in order to facilitate the communication and transportation of people and goods, we can cite structures such as roads, tunnels, bridges, viaducts, etc., as well as other structures that are used for the protection of the downstream areas, especially people and goods.

We will in the following lines show using some illustrations and demonstrating the potential of wood that it contains that the Democratic Republic of Congo, by exploiting it correctly, will be able to use it for its development.

Civil engineering includes the construction of bridges, dams, urban hydraulic systems (sewers and drinking water supply), roads, environmental management (waste water treatment, waste management) and land surveying (land measurement).

Civil engineering is a specialized and very broad field. It is the field of urban planning whose function is to build and, more generally, to implement land-use planning decisions.

There are two main areas within civil engineering:

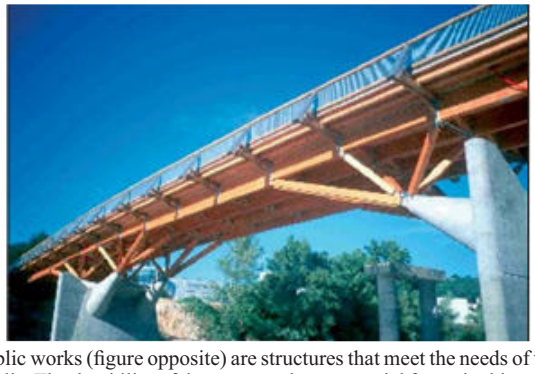
- the building
- public works

1. The building

In the building sector (figure opposite), investors come mainly from the private sector and their needs often correspond to an economic purpose. The structure of the structure is generally not very preponderant, because functionality and aesthetics are preferred. Buildings include :

- houses, buildings, hotels
- offices, administrative buildings, schools, gymnasiums
- stores, shopping centers
- factories... etc.

2. Public works



Public works (figure opposite) are structures that meet the needs of the public. The durability of the structure is an essential factor in this case. Public works include:

- crossing structures (bridges, tunnels, ...)
- rail and road networks, navigable network (canals), ports...
- public facilities (purification, waste treatment, ...)
- power plants (coal, nuclear, geothermal, wind, hydraulic, ...)
- infrastructures (electricity network, telecommunications, sanitation, drinking water, etc.)
- protection works (dikes, embankment reinforcement, avalanche barriers, riverbank protection, etc.)

1. WOOD AS A MATERIAL USED IN THE REALIZATION OF THESE WORKS

We calls Material any Substance (or substances) from which an object is or can be manufactured; we will give some materials which enter the realization of certain civil engineering works.

WOOD

Wood has always been present in many civil engineering works, but in recent years there has been a marked development in all fields. This development can be explained in particular:

- by the presence of more and more structured engineering, either in the form of independent engineering offices or integrated in timber construction companies ;
- by the mastery of technologies allowing to exploit all the flexibility of the material while ensuring a good durability;
- by the permanent integration of innovations;
- by an explosion of the automation of the machining in the field of

the timber frame;
- by a collective awareness of the environmental benefits of wood as a material (renewable material, quality of integration into the site, etc.).

In terms of innovation, we will highlight some current work that is promising:
- The technology of glued dowel joints: The principle here is based on the integration of metal rods sealed into the wood using adapted resins.
- The mixing of materials from wood-based construction components: This technology requires in-depth studies in order to master the gluing between two materials with different behaviours under various stresses (temperature, humidity...).
- The mix of components to constitute a structure: Metal is more and more used in complementarity with wood for civil engineering works. It is intended for assemblies and bracing elements, guy wires or various tie rods. Concrete is also used in combination with glued laminated wood, particularly for the design of bridge decks.
- Bi-oleo thermal treatment: This is a new process for improving the durability of wood. The principle is based on heating in a hot bath creating an overpressure and drying the wood, followed by a rapid transfer to a cold bath (tempering) creating a depression and thus promoting the penetration of oil such as linseed oil or others. The wood is encapsulated in its perimeter crown up to a certain depth (variable depending on the species, the treatment program, the presence of sapwood or not...), which gives it hydrophobicity characteristics. It becomes more stable, less palatable to insects and fungi by destroying certain starch-type molecules and is much less prone to external cracking, which prevents the appearance over time of localized water trapping zones. This should therefore be an element of improvement in the life span of the structures.

We propose to you to discover hereafter some examples of significant works revealing this tendency.

➢ **Road bridges**

Figure 1: Picture of the Crest Bridge France

- The Crest Bridge is to date the longest wooden bridge in France. Built in 2001, it is open to road traffic. It has a central span of 33 meters and two lateral spans of 29 meters. Its width is 8 meters and allows the installation of two traffic lanes and two lateral sidewalks. The deck is composed of 4 glued laminated wood ribs connected to a CLT Douglas slab. Oak was used for the decking and curbs.

Figure 2: Picture of the overpass of the Haute-Corrèze area in France

- The overpass of the Haute-Corrèze area was opened in 2003. It spans the A 89 freeway. It is a two-span road bridge. The primary load-bearing structure is made up of glued laminated Douglas fir beams resting on sets of supports located on the intermediate support and on the end abutments. The designer has specified here the wood in a primary load-bearing function under the protection of a deck with protective overhangs. The concrete deck rests on the wooden girder, and metal protective covers and guardrails are installed laterally.

➢ **Gateways**

Figure 3: Picture of the Pinot footbridge in Blagnac

- **The Pinot de Blagnac footbridge**

This work is an illustration of what can be designed in a multi-material mix since wood, metal and concrete cohabit in perfect complementarity. In this case, the wood is implemented in the form of two arches with a 28-meter span in glued laminated wood connected to metal profiles supporting a concrete slab by means of foot fittings at the ends of the arches and metal tie rods in the running parts.

Figure 4: Picture of the Ajoux gateway in France

- **The Ajoux Gateway**

This gateway located in Ardèche in France is an example of valorization of the local resource.

We can also mention
- **The Kizhi Pogost church on the island of Kiji in western Russia**

Figure 5: Kizhi Pogost Church

This wooden building has withstood the elements of the Earth for over 150 years and yet this spectacular church remains the tallest wooden structure in the world. This magnificent building is made entirely of wood, with the nuts and bolts on the magnificent exterior, and shows

just how strong this building material is. After the calls of the churchgoers, the wooden buildings have been renovated, but without using other materials. The impressive domes of the two churches stand out against the surrounding countryside and were designed to draw the Christian community from this remote desert to one place on a small island called Kiji on the waters of Lake Onega. The churches were built in the 18th century and the complex was finally completed without hammering a single nail or other metal fastener in 1862 when the bell tower was completed.

- **The staircase of the chapel in Loreto, New Mexico**

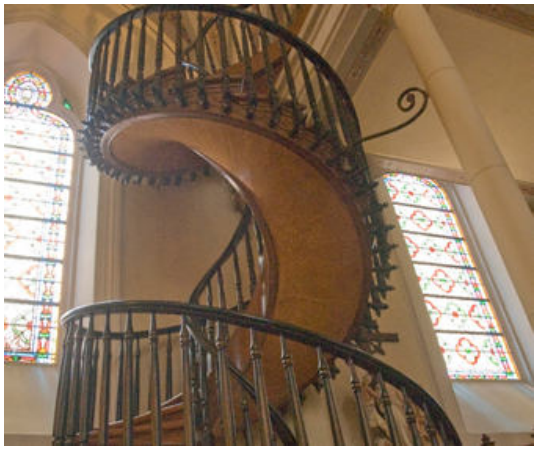


Figure 6: The staircase of the chapel of Loreto

The staircase, which is almost 6 m high, makes two complete turns around its axis before reaching the choir. It was built without any nails or glue, and does not include any form of central support. The construction itself is described as "impossible". According to some, it should have collapsed on first use, even assuming that the central spiral of the staircase is narrow enough to serve as a central support itself.

In any case, there was originally no attachment to the wall. It was only in 1887, ten years later, that the banister was added and the outer spiral was attached to the nearest pillar.

- **The ATLAS-1 in New Mexico in the United States of America**

Towards the end of the Cold War, the U.S. military became increasingly concerned about the ability of its equipment to withstand the effects of an electromagnetic pulse. In the middle of a huge desert mine in Albuquerque, New Mexico, the government built a huge wooden structure called ATLAS-I. This huge, sinister structure, which stands for Air Force Weapons Lab Transmission-Line Aircraft Simulator, was built between 1972 and 1980 to test the security of the United States against an EMP (electromagnetic pulse) attack.

The problem was that this EMP (electromagnetic pulse), generated by a high energy transmission, was reflected from the ground under the aircraft, exposing the vehicles to twice the amount of radiation they would absorb in flight. This is where the ATLAS-I test center comes in.

Figure 7: The ATLAS-I test center.

ATLAS-I was specially developed to reduce this reflection of radiation from the ground. The engineers built a huge wooden platform on a bowl-shaped depression on the desert floor. This platform formed the core of the ATLAS-I test structure and was made of wood and fiberglass to avoid interference with the electromagnetic pulse. Measuring 200 by 200 feet, it also had a 400-foot long towpath and reached a height of 12 stories. This careful design and placement allowed it to simulate an EMP (electromagnetic pulse) explosion in an airplane while preventing any reflection of radiation from the ground. It was the perfect test site for military aircraft.

- **Guardrails on the edge of roadways**

Figure 8: Examples of road safety barriers

- **Pylons and posts**

Figure 9: Examples of electricity pylons and poles

- **Miscellaneous fittings:**

Wood is present in a wide variety of outdoor structures such as: earth supports for land routes, booms, candelabras, etc...

2. WOOD POTENTIAL OF THE DEMOCRATIC REPUBLIC OF THE CONGO AND ITS EXPLOITATION

A. POTENTIAL

After South Africa, the DRC has the richest flora of the continent, with more than 11,000 species of higher plants including 3,200 endemic species (29%). Of the 30 centers of plant endemism identified in Africa, 12 are located partially or entirely in the DRC; 8 coincide with national parks. This diversity is linked to the great diversity of climatic conditions and plant formations, but it is unevenly distributed: the

richest areas are those bordering the Albertine Rift to the east, while the Central Basin is said to be poorer. This inequality is probably real and has its origin in the great variations in the extension of forests and savannas linked to the climatic variations of the last two million years. It is probably exaggerated because the Central Basin has been the subject of very little investigation and it is likely that a certain number of species have yet to be discovered there.

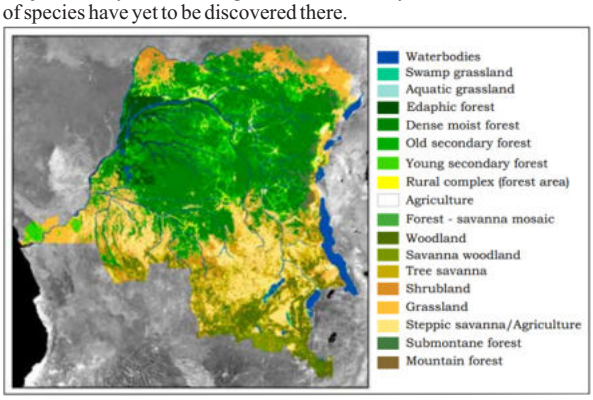


Figure 10: Forest distribution in the Democratic Republic of Congo, modified from the Land Use Map

Source: Vancustem et al. 2009

Estimates of the total area of forest cover in the DRC vary according to various sources. This seems to be due to the fact that, to date, there is no systematic forest inventory yet. The variation in estimates is due, on the one hand, to the different methods used and, on the other hand, to the observation periods carried out. For example, according to the forest map of the DRC drawn up by the Forest Inventory and Management Directorate in French *Direction des Inventaires et Aménagements Forestiers* (DIAF) of the Ministry of the Environment, Nature Conservation and Tourism in French *ministere de l'environnement et conservation de la nature et tourisme* (MECNT), the forest occupies a total area of 1,280,042.46 km^2 , representing 56.59% of the total national territory, itself estimated at 2,345,000 km^2 . The document on the state of the forests of the Congo Basin in 2008 estimates, for its part, the forest area of the DRC at 155.5 million hectares out of a total surface area of 2,329,374 km^2 of the national territory, representing 67% of the national territory of the DRC (de Wasseige et al. 2009). This estimate of the forest area of the DRC is globally confirmed by the work of Mertens and Belanger (2010) in the framework of the Forest Atlas prepared by the Global Forest Watch programme and Accroissements Annuels Moyens (MECNT). The *Organisation des nations unies pour l'alimentation et l'agriculture* (FAO) (2011) estimates that forest cover has decreased compared to the first statistics, and that it currently represents a forest area of 154,135,000 ha. This statistic is also corroborated by Blaser et al (2011). However, taking into account the work carried out by Debroux et al. (2006), the forest cover would be 145 million hectares. In concrete terms, some publications divide the Congolese landscape into three main regions (Debroux et al. 2007) :

- Dense and humid lowland forests, representing around 86 million hectares and located mainly in the Cuvette Centrale and partly in the former Bas-Congo province; this type of forest also includes the swamp forests of the Cuvette Centrale as well as mangroves, located along the country's Atlantic coast. This type of landscape ends with the forest galleries that start from the Central Basin and extend towards the former provinces of Kasai and Maniema, in the south of the country;

- The mountains and high plateaus make up the landscape of the Albertine Rift in the eastern part of the country. This landscape extends over the former administrative provinces of North and South Kivu, part of the former Province Orientale, Maniema and Katanga. The mountains and high plateaus of the eastern part of the country overlook a string of rivers (mountain lakes) located in the valley of the Albertine Rift. This landscape is shared with the countries bordering the east of the country, notably Uganda, Rwanda, Burundi, Zambia and Tanzania: three transboundary lakes at the bottom of the valleys overlook them ;

- Dry forests and the forest-savanna mosaic, an ecosystem extending in two blocks on either side of the Central Basin. It is found in the former administrative provinces of Orientale, Equateur, Katanga and Kasaï. This particular type of dry forest is known as "Miombo". Savannahs also exist in the former provinces of Bandundu and Bas-Congo.

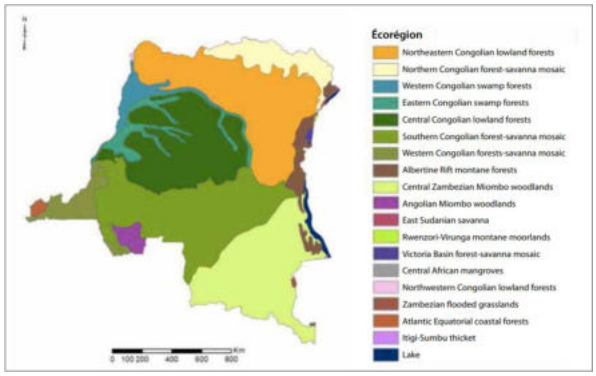


Figure 11: Mapping of WWF Ecoregions in the Democratic Republic of Congo

Source: Olson et al. 2011

This abundance of forest resources available to the DRC is capable of contributing to sustainable economic development. To this end, its forestry administration wanted to have a reference document presenting the forest species in the DRC and indicating their Minimum Exploitation Diameters (MEDs) and Average Annual Increases in French *Accroissements Annuels Moyens* (AAM), key management parameters to ensure sustainable and responsible forest management. The first edition of the Operational Guide to Forest Species in the Democratic Republic of Congo, November 2009, was drawn up on the basis of an old list produced in 1988 by the *Service Permanent d'Inventaire et d'Aménagement Forestier* (SPIAF), following forest inventories carried out in three former provinces (Bas Congo, Equateur and Orientale). These inventories had identified 753 forest species (trees and shrubs) commonly found in the sampled areas, divided into 5 commercial classes. However, the inventory work carried out in recent years, whether it be the forest management inventories carried out in forest concessions, the forest inventory of the former Bandundu Province or the forest pre-inventory work carried out on a national scale, has shown that the DRC's floristic richness is greater. In addition, changes in terminology and botanical classification made the previous list obsolete. This led to an update of the list and the addition of 217 forest species, bringing the total number of identified forest species to 970. It also made it possible to review certain management parameters where inconsistencies remained because differences had been noted between the Operational Guide published in 2009 and previous documents such as the Forest Operator's Guide or the *Service Permanent d'Inventaire et d'Aménagement Forestier* SPIAF (2005) cubage rates. Similarly, the list of species to be compulsorily inventoried during forest inventories was expanded from 77 to 91 species. In addition, following the Non-Prejudicial Trade Advice (NPA) in french Avis de Commerce Non Préjudiciable(ACNP) of May 2014 on the *Afrormosia* species (a species classified on the Red List of Threatened Species by the Convention on International Trade in Endangered Species of Wild Fauna and Flora, in French *Convention sur le commerce international des espèces de faune et de flore sauvages menacées d'extinction* (CITES)), and validated by CITES in July 2014, certain management parameters for this species have been re-evaluated, notably the DME.

B. OPERATION

As noted above, the Democratic Republic of Congo has significant forest resources that can contribute significantly to both their social and economic development. Historically and in the different provinces, there have been two systems of timber exploitation; one, industrial, carried out by international companies in large forest concessions; and the other, artisanal, by Congolese loggers, which operates essentially on the system of cutting permits. Artisanal logging includes hundreds of economic operators. Since the period of the wars, it has grown in size. At first it was carried out by smallholders who supplied wood to the local market, but today it includes economic elites, the military and police. This being the case, the activity has become important in the social, economic and commercial senses, and has the potential to generate revenue for the Congolese state. Some studies on artisanal logging have already been conducted in the DRC.

For example the study by Abdala and Lokoka (2009). This is a case study on artisanal logging in Kisangani and its surroundings. It analyses the strengths and weaknesses of forest governance. Among the factors identified are the inadequacy of legal instruments, insufficient controls, poor application of the texts on approvals and obtaining permits, and conflicts of competence between the various government departments. This study by Abdala and Lokoka is limited to the particular interest of forest activists in conservation and rural development.

Management of forest areas

The management of woodlands involves several types of decision-makers: landowners, local and group leaders, economic and political elites and, finally, government officials. The intervention of these four types of decision-makers gives rise to four different modes of forest area management depending on who decides:

- The intervention of clans in the allocation of land: this is the intervention of heads of families and landowners and is based on customary principles. These customary principles imply that the native families of the villages exercise their traditional power over their land, which is theirs by virtue of custom. As families or clans are sub-units in the customary structure, the benefits of land under artisanal logging are either for all ethnic groups5 or for the clans6 , depending on the customary land area. The clan mode applies to negotiations of land exploitation rights and specifically to negotiations over trees in their customary space.

- Customary intervention: this is the most common form of intervention in the management of forest areas in the zone, and is carried out by the chiefs of localities and groupings; the chiefs of localities do not all have the same powers, at least as far as rights of use are concerned, although they do not have rights over trees.

- Political intervention: this is the intervention of the political and economic "elites," whether indigenous or not. These 'elites' are people who have a lot of political influence and who operate under the cover of certain people in the village, economic operators that they introduce into the village; they often have a harmful role in the sector, among other things through their influence peddling.

- The intervention of the administration: this is that of those who apply forestry regulations and therefore concerns the representatives of the forestry administration. It should be noted that the Congolese population is totally lacking in knowledge about sustainable environmental management and, above all, sustainable forestry management. This lack leads to irresponsible and devastating behavior. To make up for this deficiency, the various players should be made aware of and trained in such management. It is first of all the State that should provide the mechanisms for such training through the popularization of the texts promulgated on forests and, above all, much more use should be made of this wood in civil engineering. At present, the Congolese State is not doing this work. It is the non-governmental organizations, replacing the State in this domain, that train and inform the population as much as they can about the forest. By means of environmental education, each actor can correctly fulfil his or her mission: the administration knows what taxes are required and at what rate; loggers need to know the conditions of their profession as well as their rights and obligations. The people themselves must not cut down just any tree under any pretext, and other actors (associations, notables, etc.) must carry out the monitoring work.

CONCLUSION

The current socio-economic and socio-political systems do not seem to offer the forests of the Democratic Republic of Congo the possibility of sustainable and equitable management, and lack a strategic plan that can serve as a decision-making tool for the economic and social development of local populations and indigenous peoples in territories with immense timber potential. If today this chaotic situation of artisanal exploitation's fallout is of concern to the forestry administration, there should be a return of tax revenue in the form of retrocession to decentralised administrative entities to enable the contribution of artisanal exploitation to local development and the fight against poverty to be assessed and corrected.

The examples that we have mentioned throughout our development show how wood can be used in an optimal way as a civil engineering material by constructing on the one hand engineering structures such as footbridges and other bridges, buildings and all other structures important for the development of local populations and consequently the development of the Democratic Republic of Congo.

Moreover, the objective of the examples presented is to demonstrate that it is possible to reconcile the development of the Democratic Republic of Congo with the use of other resources or potentials other than mineral resources. As the Democratic Republic of Congo contains a large amount of wood still unexploited and sometimes poorly and/or under-exploited, this requires a significant, qualified and decisive intervention of the Engineering Geology and Geotechnics, the competent Administrative and Legal Institutions, which implies that the professionals are well prepared and competent.

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